

## PROCESS CONTROL IN INJECTION MOULDING MACHINE

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### ABSTRACT

*Injection moulding is one method used to convert a polymer feedstock into the a final product. The process require process control technology to provide a workable process at economic cost and to provide a consistent product within specification. This paper presents an overview of process control in the injection moulding machine.*

### Introduction

Process control technology in polymer processing is an intentional adjustment of machine conditions to keep the plastics behaviour and finished part properties consistent. The introduction of process control technology to the injection moulding industry had its early beginning in the mid 1950s as a result of research in sensor technology and control techniques by major resin suppliers. At the 1968 Plastic Show in Chicago solid state machine logic and closed-loop adaptive process control was introduced to the industry. With the development of microcomputers, the process control technology used in the injection moulding process became more advanced. Nowadays, a modern injection moulding machine is equipped with a sophisticated process control system for high performance.

### Factors Causing Product Variation

The properties of an injection-moulded product are not the same from cycle to cycle. The factors that cause the product properties to vary can be classified as follows:

#### (a) Environmental Factors

Environmental factors such as ambient temperature and humidity can affect the performance of the injection moulding machine and also the condition of the moulding material. The ambient temperature could influence temperature of the water used for cooling in mould, feed hopper throat and hydraulic system, this giving rise to variations in the machine performance and hence product properties. At high humidity, the moulding material may absorb water and this will affect the properties of the product.

#### (b) Material Consideration

The material used for in the injection moulding process must be clean and free of impurities such as metal, water and volatiles. If the polymer is contaminated, this may affect the viscosity of the polymer melt and thus will affect the mould filling phase. Some materials need to be dried before being processed, water in the case of Nylon will influence the properties in the product. Metal contamination to the polymer could cause serious machine damage if it passes through the injection unit.

(c) Machine Variations

Machine performance affects the repeatability of the product properties. Machine variations arise due to wear, decomposition of polymer and electrical and hydraulic system problems.

Wear generally occurs when two components of the machine are moving relative to one another. Wear can occur in the injection unit, clamping unit and mould. Generally the wear in all these components is caused by abrasive materials such as the glass fibre in glass-fibre-reinforced thermoplastics.

Decomposition of the polymer, for example PVC, being processed can occur in the mould and screw. These components need to be cleaned if the materials being processed are readily degradable and the degradation products cause problems. In the case of PVC, problem may arise as a result of the acidic nature of the degradation products.

Electric problems can arise as a result of voltage variations. Voltage variations can occur when there is a lot of demand placed on the power supply. The variations can affect the performance of induction motors, heating devices and solenoids. Such factors affect the performance of the moulding machine.

Hydraulic problems include the contamination of the hydraulic fluid with dust. The contamination will affect the performance of the hydraulic system and thus the machine. Also when the hydraulic fluid gets hot, the viscosity of the hydraulic fluid will fall and the performance of the hydraulic system will also fall. If the hydraulic fluid is too cold, the viscosity will rise and it will affect the movement of the fluid in the hydraulic system.

## Techniques of Process Control

(a) Relay logic

Relay logic was the earliest type of sequence control for injection moulding machines and is still widely used. Relay logic uses electromechanical relays and hard wiring to affect the proper sequencing of the various functions of the moulding machine. The disadvantages of relay logic are:

- (i) It's reliability. The electromechanical contacts and the solenoids which switch them have a limited life.
- (ii) Lack of flexibility. The relay technology can only be used for sequencing, it is not capable of being used for the feedback control systems.

(b) Solid State Machine Logic

Solid state machine logic was developed in the 1960's and by mid 1970's, solid state control was widely used in injection moulding. Solid state logic consists of electric components such as resistors and transistors mounted onto printed circuit boards. Such boards contain a variety of circuits, for example those use for timing, machine sequencing and switching. In general, such solid-state circuitry are more reliable than the electromechanical devices they replaced and this is partly due to the reduced number of electrical connections which are required. However these types of system are very difficult to troubleshoot.

(c) Microprocessors

A microprocessor-based controller performs tasks in a sequential manner and is guided through its many task by a software program. The software is located in the memory of microprocessor in the form of a Read Only Memory (ROM), Program Read Only Memory (PROM) or Random Access Memory (RAM). The

advantage of microprocessor control is that it not only performs the logic functions but also interprets data from sensors such as a thermocouple on the machine, analyzes this information and produces outputs or actions. The design of the microprocessor-based control system provides a flexible and highly capable process control. As a result, the use of microprocessors for process control has developed rapidly.

### **Application of Process Control in Injection Moulding Machine**

Individual closed-loop process control systems are required in order to ensure that an injection moulding machine operates consistently. All of the individual process control closed-loop systems need a sensor to provide feed back signal. The following are some examples of the application of process control in an injection moulding machine.

#### **(a) Injection Speed Control**

In the closed-loop control of the injection speed (Figure 1), there is a positional transducer attached to the injection screw and a proportional valve in the hydraulic system, this regulating the hydraulic flow to the injection cylinder. The screw position versus time profile is compared to the setpoint injection speed and the difference between two values is amplified and serves as the command for the proportional valve. The repeatability of the injection speed is important because it influences the mould filling phase, variation in speed of filling possibly giving rise to variations in component properties.

#### **(b) Holding Pressure Control**

The holding pressure closed-loop control system (Figure 2) consists of a hydraulic pressure transducer and an electrical-pressure regulator on the principal hydraulic circuit. The holding pressure versus time profile is measured and compared to the setpoint. Any difference in the two values causes a correction to the system and a signal is sent to the electrical-pressure regulator. The stability of the holding pressure affects the repeatability of the packing phase, variations possibly giving rise to overpacking of the mould components.

#### **(c) Temperature Control System**

Temperature control systems are usually installed for the control of barrel and mould temperature. The temperatures of the various parts of the machine are generally sensed using thermocouple and are compared to the setpoint temperature. Any deviation will cause the controller to produce a suitable response.

### **Conclusion**

The process control improves machine performance in response to external perturbation and gives more consistent results than the normal process. As a results, plastics manufacturer's using injection moulding machine must concern about the process control technology in order to produce quality product consistently.

## References

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Figure 1 Injection Speed Control

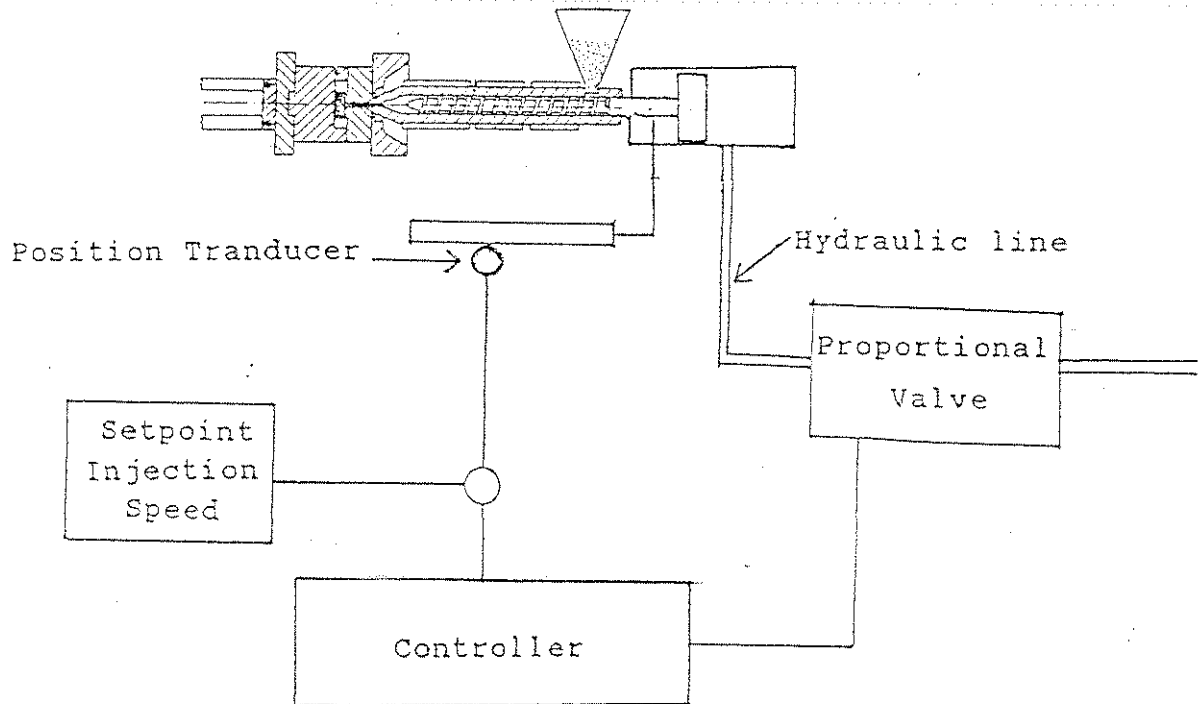


Figure 2 Holding Pressure Control

